REVISTA ELETRÔNICA
CIENTÍFICA DA UERGS

Nutritional evaluation and bioactive compounds of flours of unconventional edible roots

Larissa Almeida Alves
Universidade do Estado da Bahia (UNEB).
E-mail: nutlari.alves@gmail.com, http://lattes.cnpq.br/8744637338515697

Amanda de Jesus Silva
Universidade do Estado da Bahia (UNEB).
E-mail: amandasilvaprof@gmail.com, http://lattes.cnpq.br/7726082355881053

Isabela da Silva Caldas Rodrigues
Universidade do Estado da Bahia (UNEB).
E-mail: bela_biologia@hotmail.com, http://lattes.cnpq.br/3941783042880180

Larissa Carolina Teixeira
Universidade do Estado da Bahia (UNEB).
E-mail: larissactd@gmail.com, http://lattes.cnpq.br/3050764297205284

Uerisleda Alencar Moreira
Universidade Federal da Bahia (UFBA).
E-mail: uerisleda@yahoo.com.br, http://lattes.cnpq.br/3203063466766701

Alex Sander Lopes da Silva
Universidade do Estado da Bahia (UNEB).
E-mail: sanderlopes@gmail.com, http://lattes.cnpq.br/8259074306421203

Clícia Maria de Jesus Benevides
Universidade do Estado da Bahia (UNEB).
E-mail: bclicia@gmail.com, http://lattes.cnpq.br/4154616951839675

ISSN 2448-0479. Submetido em: 05 out. 2022. Aceito: 12 abr. 2023.
DOI: http://dx.doi.org/10.21674/2448-0479.92.83-93

Resumo

Avaliação nutricional e compostos bioativos de farinhas de raízes comestíveis não convencionais

O setor de panificação tem buscado cada vez mais alternativas de farinhas, como as farinhas de raízes comestíveis não convencionais, com características tecnologicamente viáveis à produção industrial, maior valor nutricional e aspectos sensoriais agradáveis. Assim, este trabalho objetivou avaliar o valor nutritivo e compostos bioativos de farinhas das raízes comestíveis não convencionais: inhame-roxo (*Dioscorea alata*), tupinambo (*Helianthus tuberosus*) e *ariá (Calathea allouia)*. As determinações da umidade, proteínas e cinzas foram realizadas por métodos bromatológicos padronizados, lipídeos pelo método de Bligh-Dyer, fibra bruta total (FBT) através do aparelho Fiber Analyzer-Ankom 220 e carboidratos, por diferença. A determinação dos compostos fenólicos totais e taninos das amostras foi realizada através de métodos de análise colorimétrica. Foi observada uma variação significativa ($p < 0,05$) entre todas as amostras para a umidade (8,31 a 9,37%); proteínas (7,47 a 8,93%); cinzas (3,15 a 4,42%); lipídios (0,13 a 1,76%); fibras (0,92 a 4,85%) e carboidratos (71,52 a 78,18%). Para os compostos bioativos a variação dos fenólicos totais foi de 7,35 a 100,77 mg GAE/100g, e para os taninos 0,28 a 1,41 mg TAE/100g. O estudo mostrou que as amostras analisadas possuem significativo valor nutricional, assim como de compostos bioativos, com possibilidade de uso nas formulações de produtos alimentícios.

Palavras-chave: Farinhas; Plantas Alimentícias Não Convencionais (PANC); *Dioscorea alata; Helianthus* *tuberosus; Calathea allouia.*

Abstract

Nutritional evaluation and bioactive compounds of flours of unconventional edible roots

The bakery sector has increasingly sought flour alternatives, such as unconventional edible root flours, with technologically viable characteristics for industrial production, with greater nutritional value and pleasing consumers in their sensory aspects. So, this work aims to evaluate the nutritional value and bioactive compounds of unconventional edible root meals: purple yam (*Dioscorea alata*), Jerusalem artichoke (*Helianthus tuberosus*) and *ariá (Calathea allouia)*. Moisture, protein and ash were determined by standardized bromatological methods, lipids by the Bligh-Dyer method, total crude fiber (TCF) by means of the Fiber Analyzer-Ankom 220 device and carbohydrates by difference. The determination of the total phenolic compounds and tannins in the samples were performed using colorimetric analysis methods. A significant variation ($p<0.05$) was observed between all samples for the humidity (8.31 to 9.37%); proteins (7.47 to 8.93%); ash (3.15 to 4.42%); lipids (0.13 at 1.76%); fiber (0.92 to 4.85%) and carbohydrates (71.52 to 78.18%). For the bioactive compounds, the variation of total phenolics was from 7.35 to 100.77 mg GAE/100g, and for the tannins 0.28 to 1.41 mg TAE /100g. The study showed that the analyzed samples have significant nutritional value, as well as bioactive compounds that can be used in food product formulations.

Keywords: Harina; Plantas Alimenticias No Convencionales (PANC); *Dioscorea alata; Helianthus tuberosus. Calathea allouia.*

Resumen

Evaluación nutricional y compuestos bioactivos de harinas de raíces comestibles no convencionales

El sector de la panificación há buscado cada vez más alternativas de harina, como las harinas de raíz comestible no convencionales, con características tecnológicamente viables para la producción industrial, con mayor valor nutricional y que agraden a los consumidores en sus aspectos sensoriales. Por lo tanto, este trabajo tiene como objetivo evaluar el valor nutricional y los compuestos bioactivos de harinas de raíces comestibles no convencionales: ñame morado (*Dioscorea alata*), alcachofa de Jerusalén (*Helianthus tuberosus*) y *ariá (Calathea allouia)*. Las determinaciones de humedad, proteína y cenizas se realizaron por métodos bromatológicos estandarizados, lípidos por el método Bligh-Dyer, fibra bruta total (TGF) por el dispositivo Fibre Analyzer-Ankom 220 y carbohidratos por diferencia. La determinación de los compuestos fenólicos totales y taninos en las muestras se realizó mediante métodos de análisis colorimétrico. Se observó una variación significativa ($p<0,05$) entre todas las muestras para la humedad (8,31 a 9,37 %), proteínas (7,47 a 8,93 %), cenizas (3,15 a 4,42 %), lípidos (0,13 a 1,76 %).), fibra (0,92 a 4,85%) y carbohidratos (71,52 a 78,18%). Para los compuestos bioactivos la variación de fenoles totales fue de 7,35 a 100,77 mg GAE/100g, y para los taninos de 0,28 a 1,41 mg TAE/100g. El estudio mostró que las muestras analizadas tienen un valor nutricional significativo, así como compuestos bioactivos que pueden ser utilizados en formulaciones de productos alimenticios.

Palabras clave: Agricultura sostenible; índice de velocidad de germinación; prueba de germinación; vigor.

Introduction

Wheat has been the main raw material for flour production in the world. However with the increase in demand for food, inadequate conditions for wheat cultivation in developing countries, the impact of monocultures on the environment and climate change demonstrate that the agroindustry urgently needs to develop new raw materials to promote food security (WANG; JIAN, 2022).

Furthermore, the food industry has been constantly updated in order to supply new markets and consumption demands, following new trends in the field of nutrition and consumer needs. Within these perspectives, the development of new alimentary products moves the economy in the national and international scenarios, as well as the scientific community in the search for innovations, like new inputs inserted in this sector in order to meet the special needs of individuals, such as celiacs. To this aim, great efforts were put in place to search for several flour alternatives, such as unconventional food plant flours with technologically viable characteristics for industrial production, with greater nutritional value as well as providing a pleasant sensorial experience to the final consumers, while valuing family farming (SIDDIQUI *et al*., 2022).

In addition to the physiological aspects, nutrition also has the role of combining culture, social and historical issues of food for the population (BRAZIL, 2014). In the context of food and dietary planning, to implement different food groups in the daily routine of the individual's menu is strategic to avoid monotony and nutritional deficiencies, such as meat, cereals, plants of the conventional agriculture, as well as unconventional ones (PHILIPPI; AQUINO, 2015). In addition, the inclusion of new food matrices in daily life allows the adherence of individuals with dietary restrictions, such as people with sensitivity to gluten.

The tubers are widely used in the preparation of flour and can be used to obtain gluten-free flours from unconventional edible roots. The purple yam is a tuber widely grown and consumed in Asia, North America and Brazil (mainly in northeastern states), rich in carbohydrates, fiber and comes in two morphotypes, white and purple (FERREIRA *et al*., 2020).

Jerusalem artichoke (*Helianthus tuberosus* L.) is native to North America and grows in different climate areas, from the tropics to the northern areas of agriculture (ISHNIYAZOVA *et al*., 2020). As it is a plant with strong resistance, it does not need special attention in its cultivation, such as the use of pesticides, herbicides and insecticides (LI *et al*., 2016). It also has considerable nutritional value and bioactive compounds (fructo-oligosaccharides, inulin, among others), and can be used in food production to promote human health in pharmaceuticals and a variety of processing industrial products. Inulin from this tuber has been reported to be effective in growth of probiotics such as bifidobacteria and lactobacillus, regulating the flora intestinal tract and improving the immune function of individuals (KAUR; GUPTA, 2002; ISHNIYAZOVA *et al*., 2020).

The *ariá* or Indian potato (*Calathea allouia*) is cultivated and consumed by indigenous and backland populations in the Amazon, however its consumption is reduced due to its long vegetative cycle, from ten to twelve months. Due to this fact, the ariá has been replaced in the diet of small rural producers by other types of food, such as sweet potatoes and other industrialized products (BUENO; WEIGEL, 1983). *Ariá* plays an important role in the diet, due to the great energetic potential and to the protein of good quality, since it has essential amino acids (methionine and cysteine), in addition to vitamins and minerals (BUENO; WEIGEL, 1981).

Due to the need to search for alternative flours to wheat flour by the food industry, raw materials such as unconventional edible roots can be useful, not only in relation to the greater supply of various nutrients, in special fibers, minerals and bioactive compounds, but also for providing technological and sensorial acceptance when compared with the products elaborated with conventional wheat flour.

Thus, this study aimed to analyze the nutritional characteristics and bioactive compounds from unconventional edible root meal - purple yam (*Dioscorea alata*), Jerusalem artichoke (*Helianthus tuberosus*) and ariá (*Calathea allouia*) - in order to demonstrate its applicability in the food industry as new options for the development of gluten-free products.

Materials and methods

Obtaining and preparing samples

The samples of unconventional roots, Purple Yam (*Diascorea alata*), Tupinambo (*Helianthus tuberosus*) and ariá (*Calathea allouia*) (Figure 1) were collected in a private rural property (or family and organic farming site located in the metropolitan area of Salvador – BA (-12.5071988 Latitude, - 38.6184189 Longitude, look up location on MAPs) and taken to the Laboratory of Chemical Analysis of the Department of Life Sciences at University of the State of Bahia (UNEB) to carry out the analyses.

Figure 1: Unconventional roots (A - Purple yam; B - Tupinambo; C - Ariá).

Source: the authors

The roots were previously washed and sanitized (200-250ppm of sodium hypochlorite/15 minutes), followed by peeling. Then, were chopped (1- 2 cm) and subjected to heat treatment (TT) - bleaching (water boiling for 3 minutes), followed by elimination of water and cooling, with subsequent dehydration in a forced air oven (Tecnal - mod 400/D) at 45oC/24h. To obtain the flours, after dehydration, the samples were ground in Willey Type Mill (TEC-650).

Centesimal composition and phenolic

Determinations of moisture, protein (6.5 conversion factor N2) and ash were performed according to the Association of Official Analytical Chemists (2019); lipids by the Bligh-Dyer method (BLIGH & DYER, 1959); total crude fiber (TCF) through the Fiber Analyzer-Ankom 220 device (ANKOM, 2000) and carbohydrates, by difference. The determination of the total phenolic compounds and tannins of the samples was performed according to Singleton and Rossi (1965) with modifications using the Folin Ciocalteu reagent. To prepare the standard calibration curve, a standard solution of gallic acid (100 mg/L) was used and from this, diluted concentrations between 0 and 12 mg/L (R^2 = 0.9975). As for tannins, a standard solution of tannic acid (100 mg/L) and from this, prepared diluted concentrations between 0 and 10 mg/L (R^2 = 0.9967). The measures of absorbance of gallic acid and tannic acid standards, as well as for the samples were performed at 765 nm. The results of total phenolic compounds and tannins were expressed as mg Eq of gallic acid/100g (mg GAE/100 g) and mg Eq of Tannic acid/100 g (mg TAE/100 g), respectively.

Statistical analysis

The results of the tests were submitted to analysis of variance and the means, when significant, compared by Tukey's test at 5% probability, using SAS® software version 8.0 (Statistical Analysis System Institute-SAS Institute, 1999).

Results and Discussion

The results of the analysis of unconventional root meal (purple yam, tupinambo and ariá) are shown in Table 1.

Table 1 - Nutritive value of unconventional root flours (purple yam, tupinambo and aria).

Roots	Moisture (%)	Proteins (%)	Ashes (%)	Lipids (%)	Fibers (%)	Carbohydrates (%)
Yam purple	8,52±0,06[a]	7,47±0,31[a]	3,22±0,07[a]	0,13±0,03[a]	2,51±0,11[a]	78,18±0,29[a]
Tupinambo	9,37±0,04[b]	8,93±0,07[b]	3,15±0,15[a]	1,76±0,09[b]	4,85±0,09 [b]	71,52±0,47[b]
Aria	8,31±0,10[a]	8,72±0,30[b]	4,42±0,07[b]	0,18±0,02[a]	0,92±0,02[c]	77,46±0,26a

Different lowercase letters in the same column indicate a significant difference between samples (One Way ANOVA and Tukey Test, $p<0.05$). Source: Survey data (2022).

The data in Table 1 show that there was no significant variation ($p<0.05$) between purple yam and ariá samples for moisture, lipids and carbohydrates; tupinambo and ariá samples for proteins and purple yam and Jerusalem artichoke for ashes. The other samples showed significant variation ($p<0.05$).

The moisture content (%) of the flours varied between 8.31±0.10 and 9.37±0.04, with higher for tupinambo flour and lower for aria flour, respectively (Table 1), in compliance with the Brazilian Legislation for flour, cereal starch and bran, which allows up to 15% humidity (BRAZIL, 2005). Vegetables, in general, have a high moisture content in the form of free water, which contributes to the rapid deterioration process. Thus, the dehydration of these products is an alternative as an important conservation method, whose main objective is the partial removal of water. Dehydration in an oven, for example, has as its main advantages the low cost and attainment of products with satisfactory microbiological safety (GOMEZCACERES et al., 2013).

Different researches carried out with flours obtained from tubers found moisture content between 7.05% and 14.2%, Camargo (2018) - sweet potato (Ipomoea batatas) crop, Beauregard biofortified with carotenoids; Nascimento *et al*. (2013) - Organic sweet potato (*Ipomoea batatas* L.) biofortified; Sá, *et al*. (2018) - yam (*Dioscorea* spp.); Chirsanova *et al*. (2021) - tupinambo - cultivars Amículo II and Solar; Lee *et al*. (2017) Tupinambo.

The flours had a protein content (%) that ranged from 7.47±0.31 to 8.93±0.07, being higher and lower for Jerusalem artichoke flour and purple yam, respectively (Table 1). Protein is an important nutrient for growth and development of the human being, especially when it has in its structure, essential amino acids. Therefore, foods that contain higher levels of these nutrients are important. Different concentrations of proteins in flours obtained from several tubers have been reported in literature: Sawicka et al. (2015) cited a content average of 1.09% protein on a dry basis in different Ipomoea potato cultivars; Nascimento *et al*. (2013) found 5.48% - sweet potato (*Ipomoea batatas* L.) organic and biofortified; Sá *et al*. (2018) 7.16% - yam.

Apostol *et al*. (2015), with the aim of developing richer flours nutritionally for use as functional ingredients in the food products industry, compared different proportions of wheat flour with leaves and roots of the purple yam (*Helianthus tuberosus* L). The authors cite that in 100% of wheat flour obtained 13.76% of proteins, and in contrast, the flour with 100% of the purple yam obtained 10.45% of protein. The highest content protein (18.95%) was found in 100% purple yam leaf flour. Pinar, etc. al. (2021) found, in different *Jerusalem artichoke* cultivars, protein levels that range from 5.82 to 13.36%.

Although vegetables are not recognized as a protein source, some of these have quality proteins due to the presence of essential amino acids such as lysine, threonine, isoleucine, leucine, tyrosine (MOURA *et al*., 1982; BÁRTOVÁ; BARTA, 2009; CAMARGO, 2018). Moura *et al.* (1982) studied six cultivars of the genus Dioscorea, and it was found that the protein present in three species is considered of quality, since it has sixteen different amino acids, in which eight of them are essential.

Teixeira *et al.* (2016) studied the influence of amazonian tubers (D. *trifida* - amazonia yam; C. *allouia* - *ariá* and D. *altissima* - yam) in the growth of intestinal bacteria. The best results were for the yam from the amazon and ariá. Those tubers were efficient in the production of flour source of carbohydrates, minerals and essential amino acids (tryptophan and valine), both with prebiotic effects. The aria flour presented the nutritive value: carbohydrates (81%), lipids (0.9%), proteins (4.2%), fibers (1.9%) and moisture (11.26%).

Ariá flour was also researched by Seho *et al.* (2019) and the results showed that aria flour presented an important content of carbohydrates and low-fat content. The authors cite that the functional, sensory, nutritional aspects (essential amino acids such as methionine and cysteine) of aria may play an important role in diets.

Regarding the ash content (%), which represents the total mineral content in the sample, a variation between 3.15±0.15 to 4.42±0.07 can be observed in Table 1. The jerusalem artichoke flour has the highest value and the aria flour the lowest. This variation was also observed in different works: Sawicka *et al.* (2015) and Techeira *et al*. (2018) found 1.07% and 1.86%, respectively, of the mineral content in a cultivar of *Ipomoea potato*; Nascimento *et al*. (2013) cite 2.88%, on a dry basis, in the sample of biofortified sweet potato; Sá *et al*. (2018), 3.60% in the flour obtained from yams (*Dioscorea* spp.). According to Chirsanova *et al*. (2021), jerusalem artichoke (*Helianthus tuberosus*), also known as Jerusalem artichoke, contains several minerals, such as potassium, magnesium, zinc, calcium, sodium, copper, iron and phosphorus. Other authors also investigated the ash content in *jerusalem artichokes*, finding the following values: Wang et al. (2020) - 3.13% and Catanã et al. (2018) - 6.91%. On the other hand, Sá et al. (2018) observed 3.60% ash in purple yam flour, corroborating the present work. Generally, flours from vegetable products have higher ash content compared to wheat flour (CAMARGO, 2018).

As for the lipid content (%), the values obtained from the flours in Table 1 show a variation between 0.13±0.03 (purple yam) and 1.76±0.09 (tupinambo). Apostol *et al*. (2015) observed 2.2% of lipids in *Helianthus tuberosus* flour, while Sá *et al*. (2018) found 0.08% of lipids in yam flours; Techeira *et al*. (2014), 0.34% in raw pumpkin sweet potato flour and Nascimento *et al*. (2013) 0.60% in biofortified sweet potato. According to Camargo (2018), the presence of lipids in biofortified sweet potato is important, as it influences the bioavailability of carotenoids, since they are fat soluble and need fat to be converted into vitamin A in the body.

The results obtained from the total fiber contents (%) in the flours presented values between 0.92±0.02 (ariá) and 4.85±0.09 (tupinambo). According to Resolution RDC No. 54, of November 12, 2012, which provides for the Regulation Technician on Complementary Nutritional Information, the food, to be classified with "high fiber content", must contain a minimum of 5g per serving or a minimum of 6g /100g in prepared dishes. To be defined as a "fiber source", it must contain at least 2.5g per serving or at least 3g/100g in prepared dishes, without considering the contribution of the ingredients used in their preparation (BRAZIL, 2012). Therefore, purple yam and jerusalem artichoke flour can be considered as a source of fiber.

According to Cecchi (2003), although fibers do not have nutritional value, their determination is also considered important in food products, since their structures and characteristics perform different physiological functions in the gastrointestinal tract. Jerusalem artichoke is known for its high content of inulin, which represents about 80% of the total fiber composition. The fructans inulin and oligofructose are the unavailable carbohydrates most investigated in studies involving humans, being the only ones scientifically proven to be resistant to acidity stomach, hydrolysis by mammalian gastrointestinal enzymes, and absorption gastrointestinal tract and fermented by the intestinal microbiota. In this way, they work as a prebiotic food ingredient, with beneficial potential for microbiota intestinal tract (KAUR; GUPTAR, 2002; SAENGTHONGPINIT; SAJJAANANTAKUL, 2005; GIBSON *et al*., 2004).

Chirsanova *et al*. (2021) report that the fiber content found in tupinambo ranged from 6.85 to 7.67% and Sá et al. (2018) - 5.5% in yam flours (*Dioscorea* spp.); Leonel *et al*. (2006) mentioned that the fiber content in yam flour was 3.96% and that this flour is predominantly composed of starch, but presents in its composition considerable levels of proteins and fibers and low lipid content. Camargo, (2018) found 3.43% of fiber in sweet potato flour biofortified, while Techeira *et al*. (2014) detected a higher value (5.51%) in the same type of flour. Fibers have several benefits at the gastrointestinal tract, as they may increase peristalsis, reduce the absorption of plasma cholesterol, reduce the glycemic load, feed the beneficial bacteria of the intestinal microbiota and increase fecal content (GARCIA, 2013; CAMARGO, 2018).

For the contents of total carbohydrates (%), Table 1 shows that the flours of the roots showed a variation between 71.52±0.47 (tupinambo) to 78.18±0.29 yam purple, a result that was expected in relation to the analyzed samples, since they are foods considered energetic. Nascimento *et al*. (2013) evaluated sweet potato flour biofortified and found 65.18% of carbohydrates, while the values found in other researches for flours were from: Sá, *et al.* (2018) 83.66% in yam flour; Praznik *et al*. (2015) -71.0 to 77.2% in jerusalem artichoke flour in the Topstar, Gigant and Violet from Rennes varieties. These authors cite that their tubers do not contain bitter tasting compounds and thus may be suitable for production of flour and bakery products.

Although some discrepancies were observed, in general, the data from the centesimal composition reported in this work (Table 1) were equivalent when compared to literature data. According to Chirsanova *et al.* (2021), climatic conditions, harvest date, fertilization, irrigation, genotype, parts of the plant, genetic improvement, among others, influence the total content of plant nutrients. Thus, it is suggested that these flours can be used in formulations of nutritionally enriched food products, contributing to the diversity of food consumption, and consequently, a more balanced diet.

The average values obtained from the bioactive compounds present in the flours of unconventional roots (purple yam, tupinambo and *ariá*) are presented in Table 2.

Table 2 - Total phenolics (mg GAE/100g) and tannins (mg TAE/100) of the flours of the unconventional roots (purple yam, jerusalem artichoke and ariá).

Flours	mg GAE/100g	mg TAE /100g
Purple yam	27.05 ± 0.23^{a}	0.28 ± 0.0^{a}
Jerusalem artichoke	7.35 ± 0.14^{b}	1.41 ± 0.01^{b}
Ariá	15.62 ± 0.81^{c}	0.16 ± 0.00^{c}

Different lowercase letters in the same column indicate significant difference between samples (One Way ANOVA and Tukey Test, $p<0.05$). Source: Survey data (2022).

Polyphenols are substances scientifically recognized for their potential antioxidant, being found mainly in vegetables. The bioactive compounds analyzed for the flours in Table 2 showed a statistically significant difference ($p<0.05$), for the effect of the species studied, with the highest values of total phenolics (mg GAE/100g) and tannins (mg Tannic Ac./100g) were for purple yam flour (27.05 ± 0.23) and tupinambo (1.41 ± 0.01) and the lowest for jerusalem artichoke flour (7.35 ± 0.14) and aria (0.16 ± 0.00), respectively.

Several researchers have also investigated bioactive compounds in unconventional tubers. Showkat *et al*. (2019) evaluated the distribution and antioxidant activity of the main phenolic acids in the whole jerusalem artichoke plant (*Helianthus tuberosus* L.) (tuber, stem, leaf and flower) and found greater concentration of total phenolics in leaves (4.5-5.7 mg GAE/g), followed by flowers (2.1- 2.9 mg GAE/g); tubers (0.9-1.4 mg GAE/g) and stem (0.1-0.2 mg GAE/g). The condensed tannin values found by Pinar *et al*. (2021) in tupinambo was 0.95 to 1.67%. Danilcenko *et al*. (2017) also studied the distribution of compounds of bioactive substances in tubercles of jerusalem artichoke cultivated organically during the period of growth. The concentration of total phenolics varied throughout the period of growth in all tested cultivars, with the highest concentrations of these compounds in march 2014 on Rubik's tuber cv. (17.58 mg/100 g) and in May 2014 in the tubers of Albik cv. (17.22 mg/100g). When the plants started to accumulate nutrients, a significant decrease in phenolic content was estimated, considering the totals in all 3 cultivars in the month of June 2014.

The effect of heat treatment on the concentration of bioactive compounds in purple yam flour (*Diascorea alata)* was investigated in the work of Ezeocha and Ojimelukwe (2012). According to the authors, the levels of flavonoids in raw *D. alata* were 1.38% and after boiling for 30 and 60 min reduced to 0.93%, 0.65%, respectively. While the tannin content in raw *D. alata* was 0.21%, a loss of 14% occurs after boiling for 90 min. Gabilondo (2015) studied the variation of antioxidant compounds of two sweet potato cultivars (*Ipomoea batatas* L.; Lam) with orange pulp - Beauregard and Colorado INTA - during storage at 13°C. An increase in antioxidant activity and total phenolic content were observed, especially in the crop. In another work, Im *et al.* (2021) identified more than 18 types of bioactive compounds in the inner and outer layers of five purple sweet potato cultivars from the ones harvested in Korea (Sinjami, Jami, Danjami, Yeonjami and Borami), concluding that the outer layers of cultivars Sinjami and Jami showed higher concentrations, being considered potential sources of anthocyanins and other phenolics. Still in purple sweet potato, Soares *et al*. (2014) researched different cultivars and found an average value of 83.50 mg TAE/g of total phenolics, evidencing the ellagic acid predominance.

Despite the excellent perspectives for the use of flours from these vegetables, further studies are needed regarding techniques for industrial scale production and insertion of these flours in the preparation of bakery products, as well as the toxicological safety of the products produced. Purple yam, Jerusalem artichoke and aria are foods traditionally consumed for a long time, with no reports of toxicity (BUENO; WEIGEL, 1983; FERREIRA *et al*., 2020; ISHNIYAZOVA *et al*., 2020), however, we did not find studies regarding the possible toxicological risks of the flours derived from them.

Final Considerations

It is concluded that the samples of unconventional edible root meal (purple yam, tupinambo and ariá) evaluated showed significant nutritional value, as well as bioactive compounds, with the possibility of use in formulations of food products. However, it is suggested that other complementary analyses should be carried out, examples of the technological characteristics of the flours, as well as the presence of compounds with anti-nutritional properties and toxic compounds. Is it important to encourage the production of flour from these products, since it would be contributing to add value to them, strengthen sustainable family farming and develop new raw materials to promote food security.

Acknowledgement

This work has been supported by the following Brazilian research agencies: CNPq and FAPESB. We thank CNPq and FAPESB for the financial support, and the State University of Bahia (UNEB) for the structural and institutional support.

References

APOSTOL, L.; POPA, M. E.; MUSTATEA. G. Compositional Study for Improving Wheat Flour with Functional Ingredients. Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. **Food Science and Technology**, v. 72, n. 2, p. 231-236, 2015. Available in: https://doi.org/10.15835/buasvmcn--fst:11625 . Acessed on: 08 ago. 2022.

ANKOM. **Frequently asked questions**. Online. Available in: http://www.ankom.com/faqs.html. Acessed on: 08 ago. 2022.

AOAC. **Association Official methods of analysis**. 21st ed. USA: AOAC International, 2019. Available in: https://www.aoac.org/official-methods-of-analysis-21st-edition-2019/.
Acessed on: 08 ago. 2022.

BÁRTOVÁ, V.; BÁRTA, J. Chemical Composition and nutritional value of protein concentrates isolated from potato (Solanum tuberosum L.) fruit juice by precipitation with etanol or ferric chloride. **Journal of Agricultural and Food Chemistry**, v. 57, n. 19, p. 9028-9034, 2009.

BLIGH, E.G.; DYER, W.J. A rapid method of total lipid extraction and purification. **Canadian Journal of Biochemistry and Physiology,** v. 37, n. 8, p. 911-917, 1959. Available in: https://doi.org/10.1139/o59-099. Acessed on: 08 ago. 2022.

BRASIL. Ministério da Saúde. Agência Nacional de Vigilância Sanitária (ANVISA). Resolução da Diretoria Colegiada – **RDC n° 263, de 22 de setembro de 2005**. Regulamento técnico produtos de cereais, amidos, farinhas e farelos. Available in: https://bvsms.saude.gov.br/bvs/saudelegis/anvisa/2005/rdc0263_22_09_2005.html#:~:text=a%20sua%20publica%C3%A7%C3%A3o%3A-,Art.,Regulamento%20para%20adequarem%20seus%20produtos.Acessed on: 08 ago. 2022.

BRASIL. Ministério da Saúde. Agência Nacional de Vigilância Sanitária (ANVISA). Resolução da Diretoria Colegiada – **RDC n°54 de 12 de novembro de 2012**. Dispõe sobre o Regulamento Técnico sobre Informação Nutricional Complementar. Available in: https://bvsms.saude.gov.br/bvs/saudelegis/anvisa/2012/rdc0054_12_11_2012.html . Acessed on: 08 ago. 2022.

BRASIL. Ministério da Saúde. Secretaria de Atenção Básica. Departamento de Atenção Básica. **Guia alimen-**

tar para a população brasileira [Internet]. 2. ed. Brasília: Ministério da Saúde, p.156, 2014. Available in: https://bvsms.saude.gov.br/bvs/publicacoes/guia_alimentar_populacao_brasileira_2ed.pdf . Acessed on: 08 ago. 2022.

BUENO, C. R.; WEIGEL, P. Armazenamento de tubérculos frescos de Ariá (Calathea allouia (Aubl.) Luindl). **Acta Amazônica**, v.13 n.1, p. 7-15, 1983. Available in: https://doi.org/10.1590/1809-43921983131007 . Acessed on: 08 ago. 2022.

BUENO, C. R.; WEIGEL, P. Brotação e desenvolvimento inicial de rizomas de ariá (Calathea allouia). **Acta Amazônica**, v. 11, n. 2, p. 407-409, 1981. Available in: https://doi.org/10.1590/1809-43921981112408 . Acessed on: 08 ago. 2022.

CAMARGO, V. C.S. **Avaliação in vivo de retinol em produtos (farinha e bolo sem glúten) oriundos de batata-doce (*Ipomoea batatas*) cultivar Beauregard biofortificada com carotenoides. 2018.** 174f. Dissertação (Programa de Pós-Graduação Stricto Sensu, Mestrado em Ciências da Vida), PUC-Campinas. Campinas, SP, 2018. Available in: http://repositorio.sis.puc-campinas.edu.br/xmlui/bitstream/handle/123456789/14912/ccv_ppgcs_me_Valeria_CSC.pdf?sequence=1 . Acessed on: 08 ago. 2022.

CATANÃ, L., CATANÃ, M., IORGA, E., *et al*. Valorification of Jerusalem Artichoke Tubers (Helianthus Tuberosus) for Achieving of Functional Ingredient with High Nutritional Value. **"Agriculture for Life, Life for Agriculture"** Conference Proceedings, v.1, n.1, pp.276-283. 2018. Available in: https://doi.org/10.2478/alife-2018-0041. Acessed on: 08 ago. 2022.

CECCHI, H. M. **Fundamentos teóricos e práticos em análise de alimentos.** 2ª Ed.: UNICAMP. Campinas-SP. 206p, 2003. Available in: https://doi.org/10.7476/9788526814721. Acessed on: 08 ago. 2022.

CHIRSANOVA, A.; CAPCANARI, T.; GÎNCU, E. Jerusalem artichoke (*Helianthus tuberosus*) flour impact on bread quality. **Journal of Engineering Science**, v. 28, n. 1 p. 131-143, 2021. Available in: https://doi.org/10.52326/jes.utm.2021.28(1).14. Acessed on: 08 ago. 2022.

DANILCENKO, H.; JARIENE, E.; SLEPETIENE, A.; SAWICKA, B.; ZALDARIENE, S. The distribution of bioactive compounds in the tubers of organically grown Jerusalem artichoke (*Helianthus tuberosus* L.) during the growing period. **Acta Scientiarum Polonorum Hortorum Cultus**, v.16, n.3, p. 97–107. Available in: https://doi.org/10.24326/asphc.2017.3.10 . Acessed on: 08 ago. 2022.

EZEOCHA V. C.; OJIMELUKWE P. C. The impact of cooking on the proximate composition and anti-nutritional factors of water yam (*Dioscorea alata*). **Journal of Stored Products and Postharvest Research**, v. 3, n. 13, p. 172-176, 2012. Available in: https://doi.org/10.5897/JSPPR12.031 . Acessed on: 08 ago. 2022.

FERREIRA, A. B.; MING, L. C.; HAVERROTH, M.; LIMA, M. S.; NASCIMENTO, M. M. Manejo de variedades locais de *Dioscorea* spp. Em comunidades tradicionais da Baixada Cuiabana em Mato Grosso, Brasil. **Scientia Naturalis**, v. 2, n. 1, p. 204-219, 2020. Available in: https://ainfo.cnptia.embrapa.br/digital/bitstream/item/212839/1/26994.pdf . Acessed on: 08 ago. 2022.

GARCIA, E. L **Composição dos tubérculos, extração e caracterização de amidos de diferentes cultivares de batata.** 2013. ix, 82 f. Dissertação (mestrado) - Universidade Estadual Paulista, Júlio de Mesquita Filho, Faculdade de Ciências Agronômicas de Botucatu, 2013. Available in: https://repositorio.unesp.br/handle/11449/90677. Acessed on: 08 ago. 2022.

GABILONDO, J. **Compuestos antioxidantes presentes en dos cultivares de batata (*Ipomoea batata* L.; Lam) de pulpa naranja, en el producto fresco y procesado como dulce.** Tesis doctorales. Facultad de Ciencias Exactas y Naturales. Universidad de Buenos Aires. p. 12-15, 2015. Available in: https://bibliotecadigital.exactas.uba.ar/download/tesis/tesis_n5860_Gabilondo.pdf . Acessed on: 08 ago. 2022.

GIBSON, G.; PROBERT, H.; LOO J.; RASTALL, R.; ROBERFROID, M. Dietary modulation of the human colonic microbiota: updating the concept of prebiotics. **Nutrition Research Reviews**, v. 17, n.2, p. 259-75, 2004.

GOMEZCACERES, P. L.; OLIVEIRA, F. M. N.; ANDRADE, J. S.; MOREIRA FILHO, M. Cinética de secagem da polpa cupuaçu (*Theobroma grandiflorum*) pré desidratada por imersão-impregnação. **Revista de Ciências Agronômicas**, v. 44, n. 1, p. 102-106, 2013. Available in: http://dx.doi.org/10.1590/S1806-66902013000100013. Acessed on: 08 ago. 2022.

ISHNIYAZOVA, S. A.; MUMINOV, N. N.; KHUDAYBERDIYEV, A. A.; JAMOLIDDINOVA, V. J. Jerusalem Artichoke Is A Promising Raw Material For The Production Of Dietary Dishes And Flour Confectionery. **The American Journal of Agriculture and Boimedical Engineering**, v.2, n.11, p.33-41, 2020. Available in: https://doi.org/10.37547/tajabe/Volume02Issue11-07 . Accessed on: 21 dez. 2022.

KAUR N.; GUPTA, A. K. Applications of inulin and oligofructose in health and nutrition. **Journal of Biosciences**, v. 27, n. 7, p.703e14, 2002. Available in: https://doi.org/10.1007/BF02708379 . Acessed on: 08 ago. 2022.

LEE, Y. J.; LEE, O-H.; YOON, W. B. Effect of Inulin in Jerusalem Artıchoke (*Helianthus tuberosus* L.) Flour on the viscoelatic behavior of cookie dough and quality of cookies. **Proceedings of the International Food Operations and Processing Simulation Workshop**, v.7, p.35-44, 2017.

LEONEL, M.; MISCHAN, M. M.; PINHO, S. Z.; IATAURO, R. A.; FILHO, J. D. A. Efeitos de parâmetros de extrusão nas propriedades físicas de produtos expandidos de inhame. **Food Science and Technology**, v. 26, n. 2, p. 459-464, 2006.

LI, L.; SHAO, T.; YANG, H.; CHEN, M.; GAO, X.; LONG, X., *et al*. The endogenous plant hormones and ratios regulate sugar and dry matter accumulation in Jerusalem artichoke in salt-soil. **Science of the Total Environment**, v. 578, p. 40-46, 2017. Available in: https://doi.org/10.1016/j.scitotenv.2016.06.075 .
Acessed on: 08 ago. 2022.

MOURA, L. L.; CARVALHO, M.; DE SIQUEIRA, F.A. R. Proteína e composição em aminoácidos em inhame *Dioscorea* spp. **Embrapa Agroindústria de Alimentos** - Séries anteriores (INFOTECA-E), 1982. Available in: https://www.infoteca.cnptia.embrapa.br/infoteca/bitstream/doc/415846/1/CTAADOCUMENTOS15BOLETIMTECNICODOCENTRODETECNOLOGIAAGRICOLAEALIMENTARFL06774.pdf .
Acessed on: 08 ago. 2022.

NASCIMENTO, K. O.; ROCHA, D. G. C. M.; SILVA, E. B.; BARBOSA JÚNIOR, J. L.; BARBOSA, M. I. M. J. Caracterização química e informação nutricional de fécula de batata-doce (*Ipomoea batatas* L.) orgânica e biofortificada. **Revista Verde**, v. 8, n. 1, p. 132 -138, 2013.

PHILIPPI, S.T.; AQUINO, R.C. Org. **Dietética: Princípios para o planejamento de uma alimentação saudável.** Ed. Manole: São Paulo 2015. 248p.

PINAR, H.; KARA, K.; HANCI, F.; KAPLAN, M. Composição nutricional de forragem de diferentes genótipos de alcachofra de Jerusalém. **Journal of animal and Feed Sciences**, v. 30, n. 2, p.141-148, 2021. Available in: https://doi.org/10.22358/jafs/136053/2021 . Acessed on: 08 ago. 2022.

PRAZNIK, W.; LOEPPERT, R.; VIERNSTEIN, H.; HALSBERGER, A. G.; UNGER, F. M. Dietary Fiber and Prebiotics. In: Ramawat, K., Mérillon, JM. (eds) **Polysaccharides.** Springer, Cham., 2015. Available in: https://doi.org/10.1007/978-3-319-16298-0_54 . Acessed on: 08 ago. 2022.

SÁ, A. R. A.; LIMA, M. B.; SILVA, E. I. G.; MENDES, M. L. M.; MESSIAS, C. M. B. O. Caracterização físico--química e nutricional de farinhas obtidas de inhame (*Dioscorea* spp.) e taro (*Colocasia esculenta*) comercializados em Petrolina-PE. **Saúde (Santa Maria)**, v. 44, n.3, p.1-9, 2018.
SAENGTHONGPINIT, W.; SAJJAANANTAKUL, T. Influence of harvest time and storage temperature on characteristics of inulin from Jerusalem artichoke (*Helianthus tuberosus* L.) tubers. **Postharvest Biology and Technology**, v.37, p.93-100, 2005.

SAWICKA, B.; MICHAŁEK, W.; PSZCZÓŁKOWSKI, P. The relationship of potato tubers chemical composition with selected physiological indicators. **Zemdirbyste-Agriculture**, v. 102, n. 1, p. 41−50, 2015. Available in: https://doi.org/10.13080/z-a.2015.102.005 . Acessed on: 08 ago. 2022.

SEHO, R.E.Y.; AGUIAR, J.P.L.; SOUZA, F.C.A. Application of pulp and peels of ariá (*Calathea allouia*) in dehydrated soups formulations. **Academia Journal of Agricultural Research**, v.7, n.6, p.133-142, 2019. Available in: https://doi.org/10.15413/ajar.2019.0601 . Acessed on: 08 ago. 2022.

SOARES, I.F.O.; FAKHOURI, F.M.; GIRALDI, A.L.F.M.; BUONTEMPO, R.C. Síntese e caracterização de biofilme de amido plastificado com glicerol ou triacetina. **Foco**, v. 5, n. 7, p.1-20, 2014.

SHOWKAT, M. M.; FALCK-YTTER, A. B.; STRÆTKVERN, K. O. Phenolic Acids in Jerusalem Artichoke (*Helianthus tuberosus* L.): Plant Organ Dependent Antioxidant Activity and Optimized Extraction from Leaves. **Molecules**, v.24, n.18, p. 3296, 2019.

SIDDIQUI, S. A.; MAHMUD, M. M. C.; ABDI, G.; WANICH, U.; FAROOQI, M. Q. U.; SETTAPRAMOTE, N.; KHAN, S.; WANI, S. A. New alternatives from sustainable sources to wheat in bakery foods: Science, technology, and challenges. **Journal of Food Biochemistry**, v. 46, n. 9, e14148, 2022. Available in: https://doi.org/10.1111/jfbc.14185. Acessed on: 21 dez. 2022.

SINGLETON, V. L.; ROSSI, J. A. Colorimetry of total phenolics with phosphomolybidic-hosphotungstic acid reagent. **American Journal of Enology and Viticulture**, v.16, p.144-158, 1965. Available in: https://www.ajevonline.org/content/16/3/144 . Acessed on: 08 ago. 2022.

STATISTICAL ANALYSIS SYSTEM INSTITUTE. **SAS for Windows**. Versão 8.0 SAS®. Carry, 1999.

TECHEIRA, N.; SÍVOLI, L.; PERDOMO, B.; RAMÍREZ, A.; ROSA, F. Caracterización fisicoquímica, funcional y nutricional de harinas crudas obtenidas a partir de diferentes variedades de yuca (*Manihot esculenta crantz*), batata (*Ipomoea batatas* lam) y ñame (*Dioscorea alata*), cultivadas em Venezuela. **Interciencia**, v. 39, n.3, p. 191-197, 2014.

TEIXEIRA, L. S.; MARTIM, S. R.; SILVA, L. S. C.; KINUPP, V. F.; TEIXEIRA, M. F. S.; PORTO, A. L. F. Efficiency of Amazonian tubers flours in modulating gut microbiota of male rats. **Innovative Food Science and Emerging Technologies**, v.38, p. 1–6, 2016.

WANG, Y.; ZHAO, Y.; XUE, F.; NAN, X.; WANG, H.; HUA, D.; LIU, J.; YANG. L.; JIANG, L.; XIONG, B. Nutritional value, bioactivity, and application potential of Jerusalem artichoke (*Helianthus tuberosus* L.) as a neotype feed resource. **Animal Nutrition**, v. 6, n. 4, p. 429-437, 2020.

WANG, Y.; JIANG, C. Sustainable plant-based ingredients as wheat flour substitutes in bread making. **Science of Food**, v. 2022, n. 6, 2022. Available in: https://doi.org/10.1038/s41538-022-00163-1. Acessed in: 21 dez. 2022.